



GOES-R Space Weather L2+ Algorithms



GOES-R3 Review

**William F. Denig, Chief
Solar & Terrestrial Physics Division
NOAA/NESDIS/NGDC**

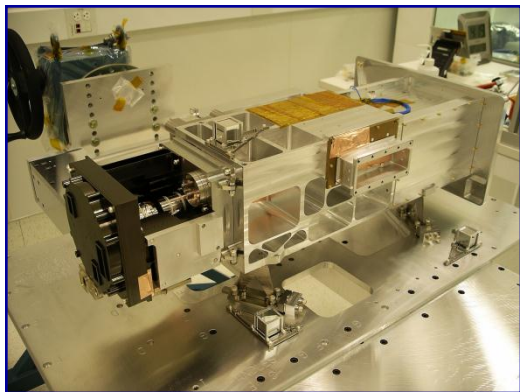
+1 303 497-6323

William.Denig@noaa.gov



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SWx Instrument Overview (H/W & L1b)



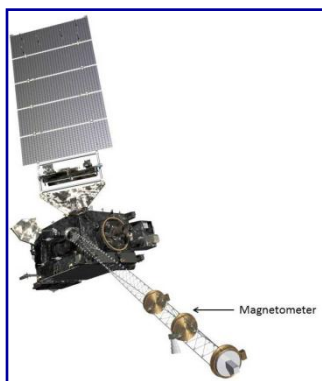
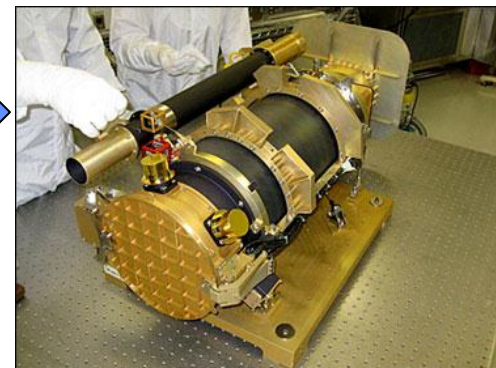
← **EUV and X-Ray Irradiance Sensors (EXIS)**

- Extreme Ultraviolet Sensor (EUVS)
- X-Ray Sensor (XRS)
- EUVS/XRS Electrical Box (EXEB)
- Sun Positioning Sensor (SPS)

Sensor Manufacturer: LASP

Solar UltraViolet Imager (SUVI) →

Sensor Manufacturer: LMATC



← **Magnetometer (MAG)**

Sensor Procurement: LM

Space Environment In-Situ Sensor (SEISS) →

- Magnetospheric Particle Sensor Low (MPS-LO)
- Magnetospheric Particle Sensor High (MPS-HI)
- Solar & Galactic Proton Sensor (SGPS)
- Energetic Heavy Ion Sensor (EHIS)

Sensor Manufacturer: ATC





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Space Weather L2+ Product Overview

Product Set 1 Complete

XRS.04: One-minute averages for both long and short channels
EUVS.03: One-minute averages of broad spectral bands
SEISS.16: One-minute averages - all MPS channels
SEISS.17: Five-minute averages - all MPS and SGPS channels
SEISS.18: Convert differential proton flux values to integral flux values
MAG.07: MAG data in alternate geophysical coordinate systems
MAG.08: One-minute averages
MAG.09: Comparison to quiet fields
SUVI.07: Composite (wide dynamic range) images
SUVI.09 and .10: Fixed and running difference images

Product Set 2 Complete

XRS.05: Calculate the ratio of the short over long channels
XRS.09: Daily Background
XRS.07: Event Detection with one-minute data
EUVS.03D: Daily averages of broad spectral bands
EUVS.04: Event Detection
SEISS.19: Density & temperature moments & level of spacecraft charging
MAG.10: Magnetopause crossing detection
SUVI.12: Coronal Hole Images
SUVI.19: Thematic Map

Product Set 3 In Process

XRS.10: Flare Location
EUVS.05: Multi-wavelength proxy
SEISS.20: Event detection based on flux values
MAG.12: Sudden Impulse (SI) detection
SUVI.13: Bright Region Data
SUVI.14: Flare Location (XFL) reports
SUVI.15: Coronal Hole Boundaries
SUVI.17: EUV Narrow Band Irradiance

Legacy Product
New Product

- 28 Level 2+ Space Weather Products in three product sets
- 19 are operational legacy, 9 are new or have experimental heritage



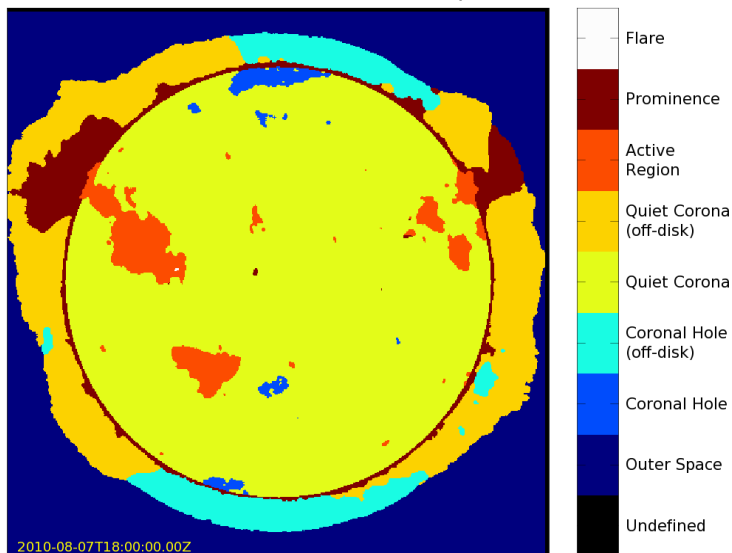
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Space Weather Product Set 2 - Examples

SUVI.19

Thematic maps will be used to identify distinct solar regions including flares, prominences, coronal holes, active regions and corona. This technology will be used for the GOES-R proving ground.

Solar Corona MAP Thematic Map

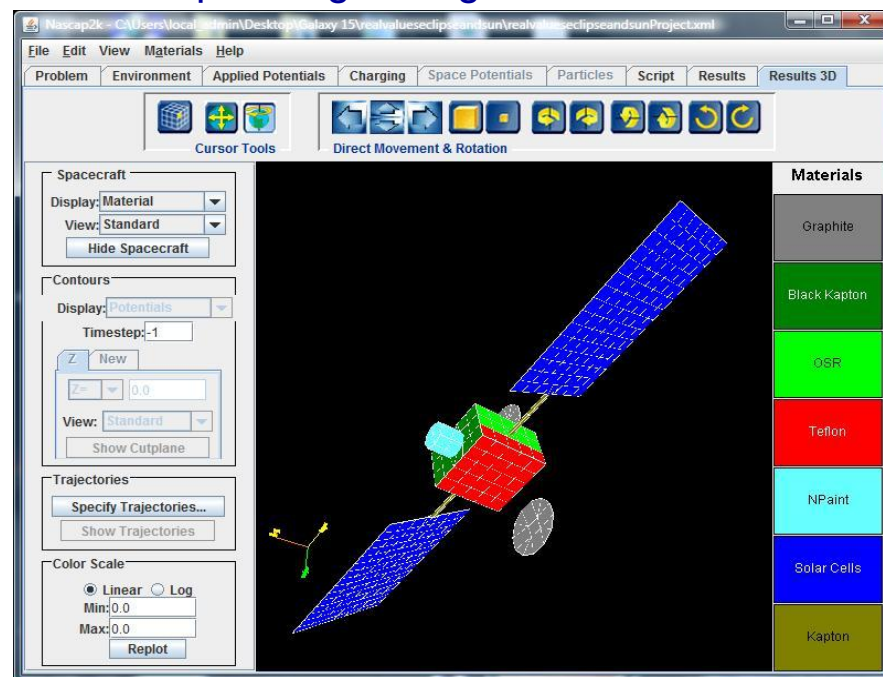


Proxy data from the NASA Solar Dynamics Observatory's Atmospheric Imaging Assembly.

GOES-RRR 23 Sep 2011

SEISS.19

Determination of the local environment used to model spacecraft potentials and assess Electro-Static Discharge (ESD) risks. Image below is the NASCAP run of Galaxy-15 for the 05-April-10 geomagnetic storm¹.



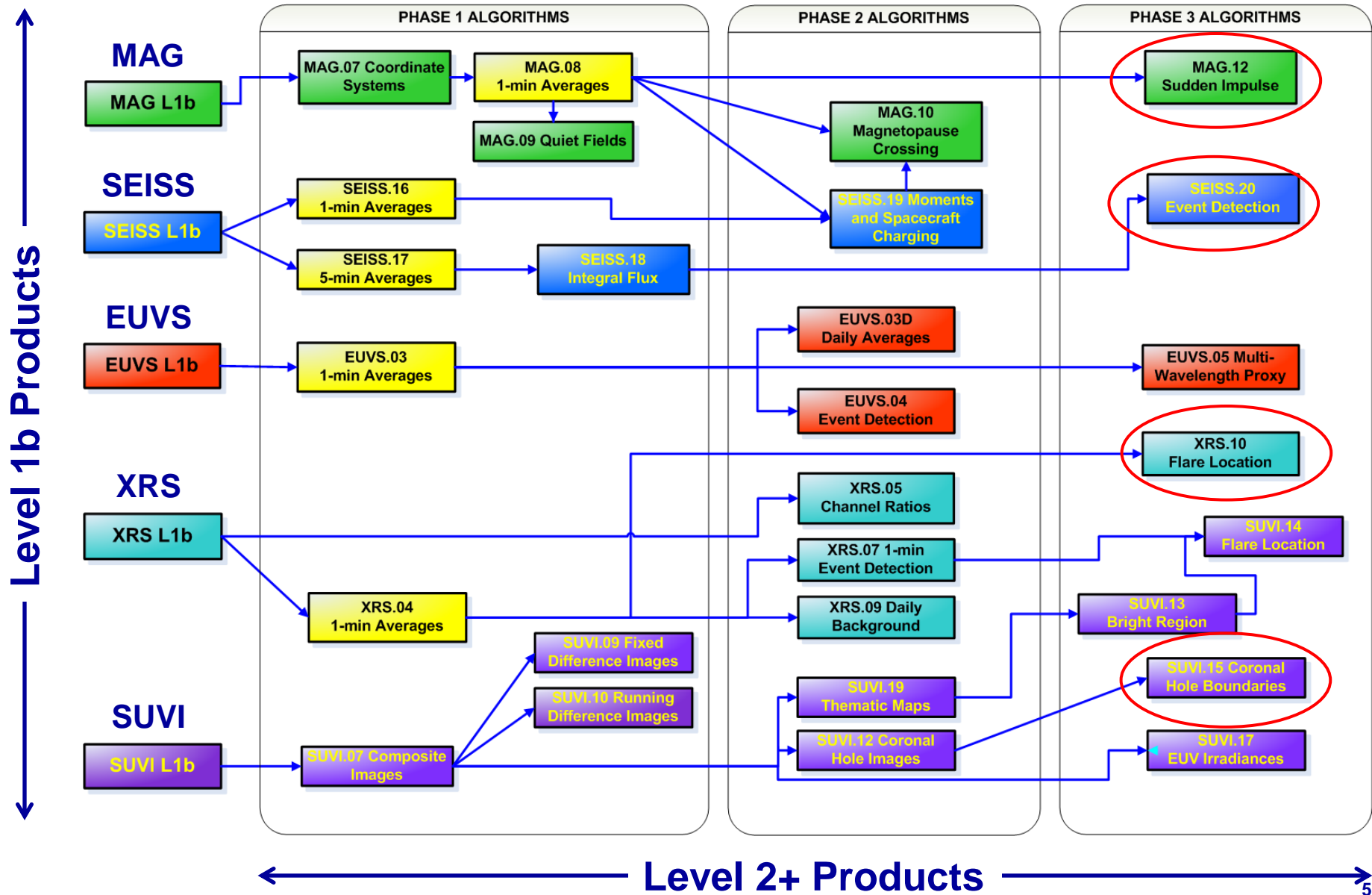
Proxy data from GOES NOP.

¹Published by Ferguson, Denig, and Rodriguez, AIAA, 2010 4



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Product L1b/L2+ Interdependencies





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Selected New Products – Under Development

XRS-10: Flare Location

Purpose: Automate the location of solar flares using the XRS instrument to aid in evaluation of impacts on earth-based and satellite systems

Usage: SWPC solar flare forecast aid

Current Status: In research

MAG-12: Sudden Impulse Detection

Purpose: Automate the detection of impulsive magnetospheric events and provide shock wave impacts

Usage: SWPC geomagnetic storm and variation specifications and forecasts

Current Status: On hold until scientist is hired

SEISS.20: Event Detection

Purpose: Adapt current SEP Event Detection algorithm to SEISS SGPS protons, define enhanced event detection using new SEISS measurements with dosimeters (MPS-HI) and heavy ions, especially iron (EHIS)

Usage: SWPC proton event warnings and NGDC satellite anomaly assessments

Current Status: In research

SUVI.15: Coronal Hole Boundaries

Purpose: Automate the identification and location of coronal hole boundaries on solar images

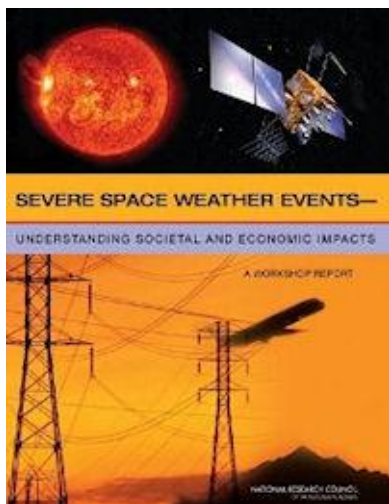
Usage: SWPC coronal hole maps

Current Status: Scientist just hired



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Space Weather (SWx) Impacts



NRC estimate of the economic impact of a severe space weather event exceeds \$1T in the first year – full recovery could take 4 to 10 years. (2008)

The NOAA Space Weather Prediction Center provides 24x7 monitoring. →



President Obama/Prime Minister Cameron

At the World Meteorological Congress the U.S. and U.K. agreed to work together with other international partners to implement a fully operational global space weather warning system. (2011)



GOES data are critical to SWx operations



Space weather presents a variety of hazards to technical systems and human life depending on the types, strengths, timings and locations of the disturbances. (2009)

The U.K. Met Office pledges to establish a second 24x7 SWx forecast office.



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Real World Example – Galaxy 15

SPACE NEWS

29th Annual International Space Dev
Chicago May 27 - 31 2010
National Space Society

Google Custom Search

Home Launch Contracts Civil Military **Satellite Telecom** Earth Observation Venture Space Policy

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04/20/10 02:05 PM ET

CASBAA Singapore Satellite Industry Forum 2010

14 June 2010
Shannon, LA Singapore

Orbital Blames Galaxy 15 Failure on Solar Storm

By Peter B. de Selding

PARIS — The in-orbit failure of the Orbital Sciences-built Intelsat Galaxy 15 telecommunications satellite April 5 was likely caused by unusually violent solar activity that week that damaged the spacecraft's ability to communicate with ground controllers, Orbital officials said April 20.

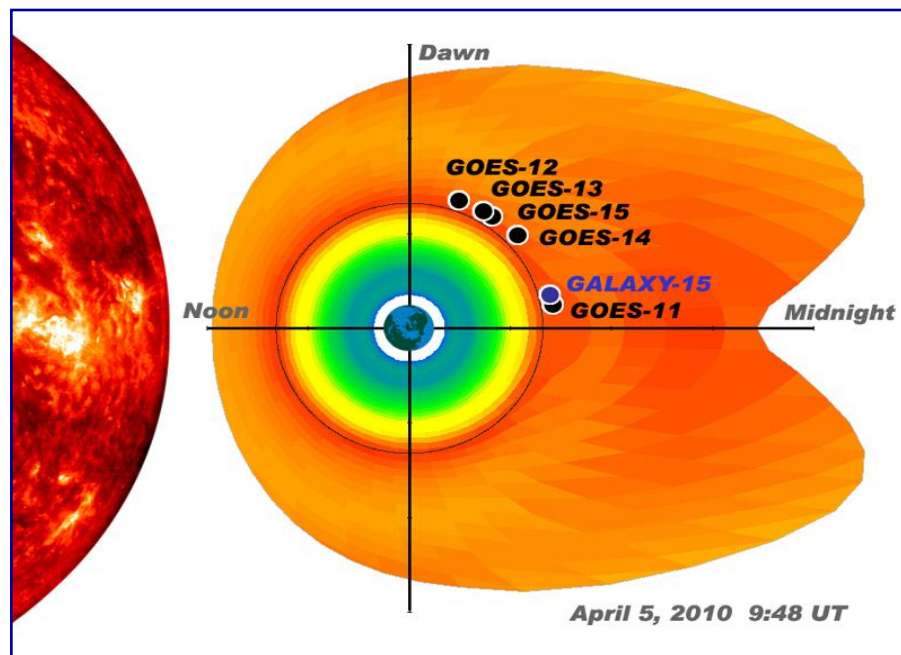
Similar events have occurred, if less severely, on other Orbital spacecraft.

Galaxy 15 satellite. Credit: Orbital Sciences photo

[Enlarge Image](#)



In April 2010 the Galaxy 15 satellite suffered an anomaly during an interval of heightened space weather. NOAA's environmental assessment for this period concluded that Galaxy 15 satellite was at increased risk of ESD. While not officially attributing the failure to space weather the satellite builder acknowledged that ESD was the root cause. ***The availability of GOES data was critical to NOAA's environmental assessment.***





GOES-R Space Weather

GOES-R Space Weather Team

	Name	Organization	Functional Area
Core Team	Mary Shouldis	CIRES	Management
	Juan Rodriguez	CIRES	SEISS
	Alysha Reinard	CIRES	EXIS
	<i>Jonathan Darnel (incoming)</i>	CIRES	SUVI
	<i>CIRES New Hire</i>	CIRES	MAG
	Leslie Mayer	CIRES	MAG/SEISS
	Jim Vickroy	CIRES	SUVI
	Dave Bouwer	Space Env. Tech.	EUVS
	Steve Mueller	Univ. Colorado	EUVS
	Bill Denig	NGDC	Federal Oversight
	Janet Green	NGDC	SEISS Advisory
	Rob Redmon	NGDC	MAG Advisory
	Dan Wilkinson	NGDC	Archive
	<i>Federal New Hire (pending)</i>	NGDC	SUVI Advisory
	Steven Hill	SWPC	SUVI Advisory
	Terry Onsager	SWPC	SEISS Advisory
	Rodney Viereck	SWPC	XRS/EUVS Advisory
	Howard Singer	SWPC	MAG Advisory
	Christopher Balch	SWPC	Lead Forecaster



GOES-R Space Weather

Overall Status

- GOES R Risk Reduction Activities are researching and developing operational algorithms for existing and new space weather products
 - User requirements for improved GOES-R space weather products have presented challenges requiring new approaches and algorithms for processing and interpreting the sensor data
 - Phases 1 and 2 are complete with completion of 20 of 28 algorithm requirements met to date
- The GOES R³ activities will allow SWPC and NGDC to meet these challenges and greatly improve the functionality and overall utility of the GOES R space weather sensor suite
- The Risk Reduction team is gearing up to take on calibration and validation activities needed for the space weather sensors



GOES-R Space Weather

Functional Re-alignment – SWPC & NGDC

SWPC Focus Areas

RT Operational Support

- Space Situational Awareness
- Forecasting
- Model Transition
- Model Science
- Product Development
- Instrument Requirements
- Display Systems
- Customer Requirements
- Stakeholders

NGDC Focus Areas

Satellite Data Services

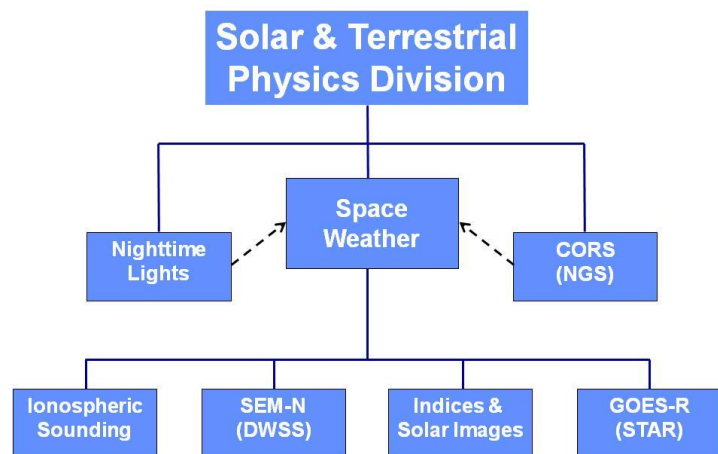
- Scientific Data Stewardship
- Cal/Val Observation Systems¹
- Post Launch Testing¹
- Algorithm Research¹
- Post-Event Analysis¹
- Instrument Science/Research¹
- Instrument Performance¹
- POES Processing¹

¹Functional Realignment from SWPC to NGDC (Ongoing)

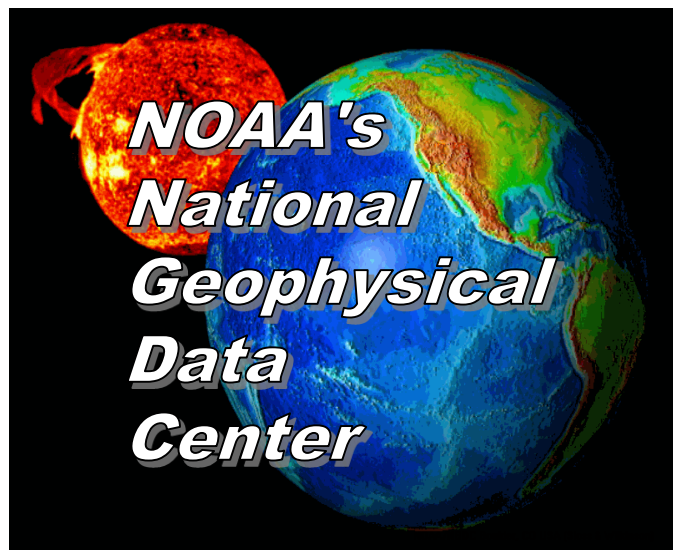


GOES-R Space Weather

NGDC Solar & Terrestrial Physics Division



Space Weather – “*The conditions on the sun and in the solar wind, magnetosphere, ionosphere and thermosphere that can influence the performance and reliability of space-borne and ground-based technological systems and endanger human life or health.*” (National Space Weather Program)



The Solar & Terrestrial Physics Division within the National Geophysical Data Center (NGDC) provides the archive, access and assessment (AAA) functions for the NOAA Space Weather program.

NGDC is also the organizational host for the World Data Center (WDC) for Geophysics, Boulder. The purpose of the WDCs is to collect, archive and distribute geophysical data and related products to world-wide users.

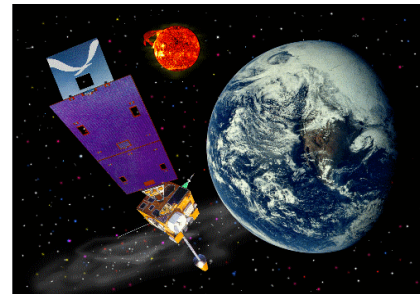


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NGDC/STP – Stewarding NOAA SWx Data

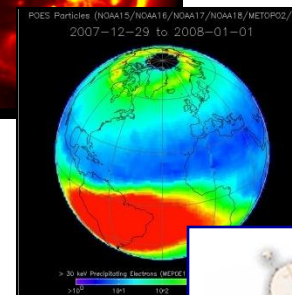
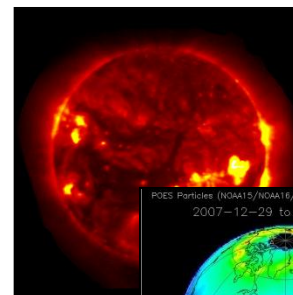
GOES Space Environment Monitor

- Geosynchronous Orbit, since 1974
- Elements: In Situ Magnetic Fields
Whole Sun X-ray Flux
Energetic Particles



GOES Solar X-ray Imager – GOES 12-15

- Geosynchronous Orbit, since 2003
- X-ray Images taken every minute
- All Data Are Online (once operational)



POES/MetOp Energetic Particle Detector

- Polar Low Earth Orbit
- Energetic Particles Archived Since 1979
- All Data Are Online



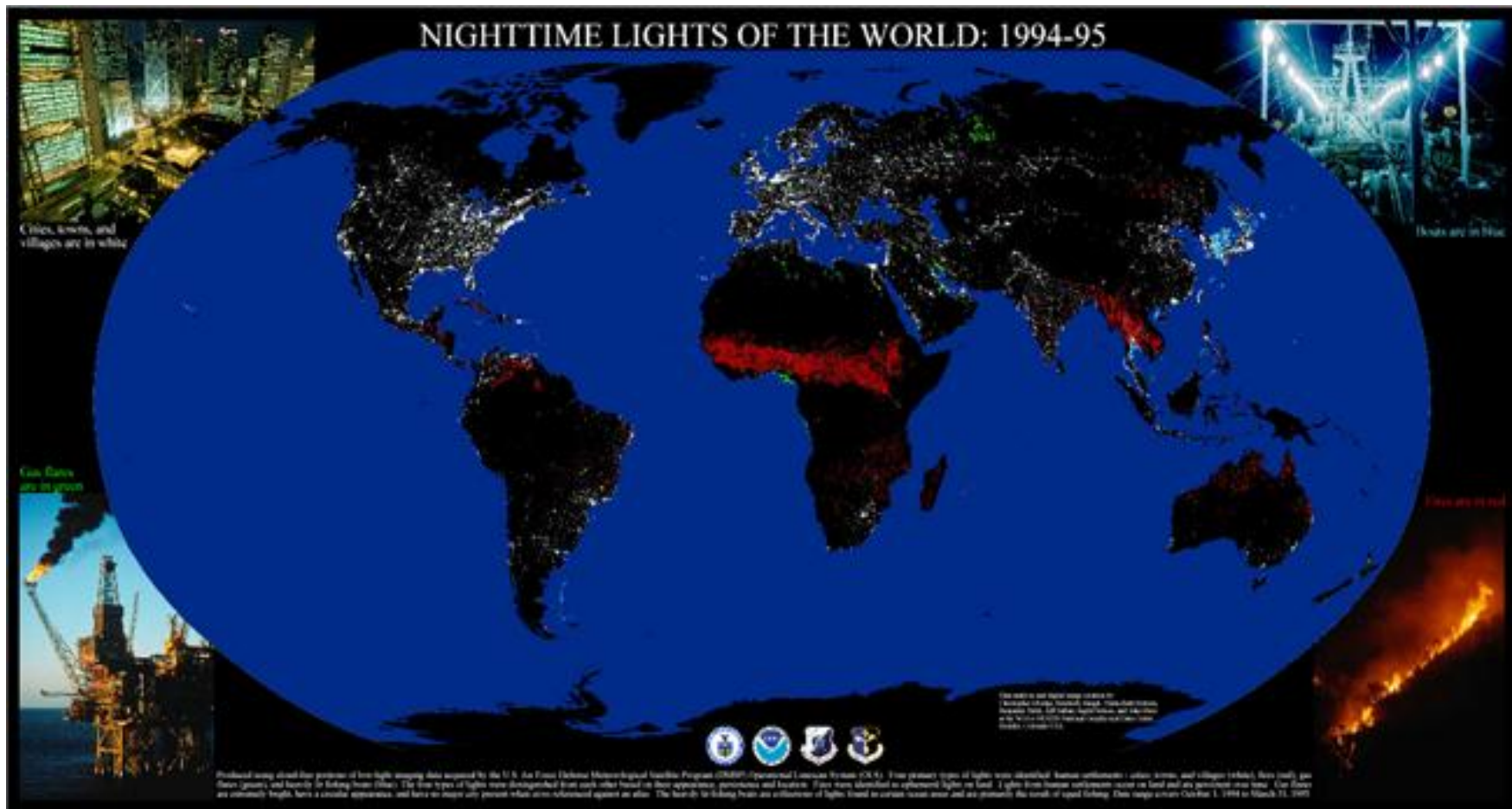
NGDC manages the CLASS Boulder node



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NGDC/STP – DMSP Nighttime Lights

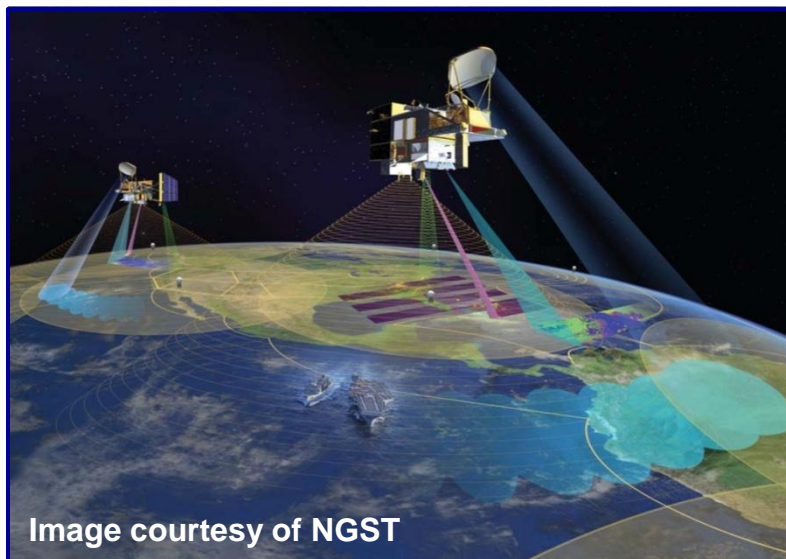
Since 1992 STP has been the principal archive for DMSP. The Earth Observation Group is responsible for the NOAA Nighttime Lights earth imagery dataset and derived products.





GOES-R Space Weather

NGDC/STP – SEM-N Algorithm Development



STP is developing algorithms for the Space Environment Monitor – Next (SEM-N) for the Defense Weather Satellite System. NGDC is coordinating internal efforts with support provided by AFRL and the JHU-APL. SEM-N is fully integrated with the Algorithm Development Language (ADL)





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Solar-Terrestrial Interactions

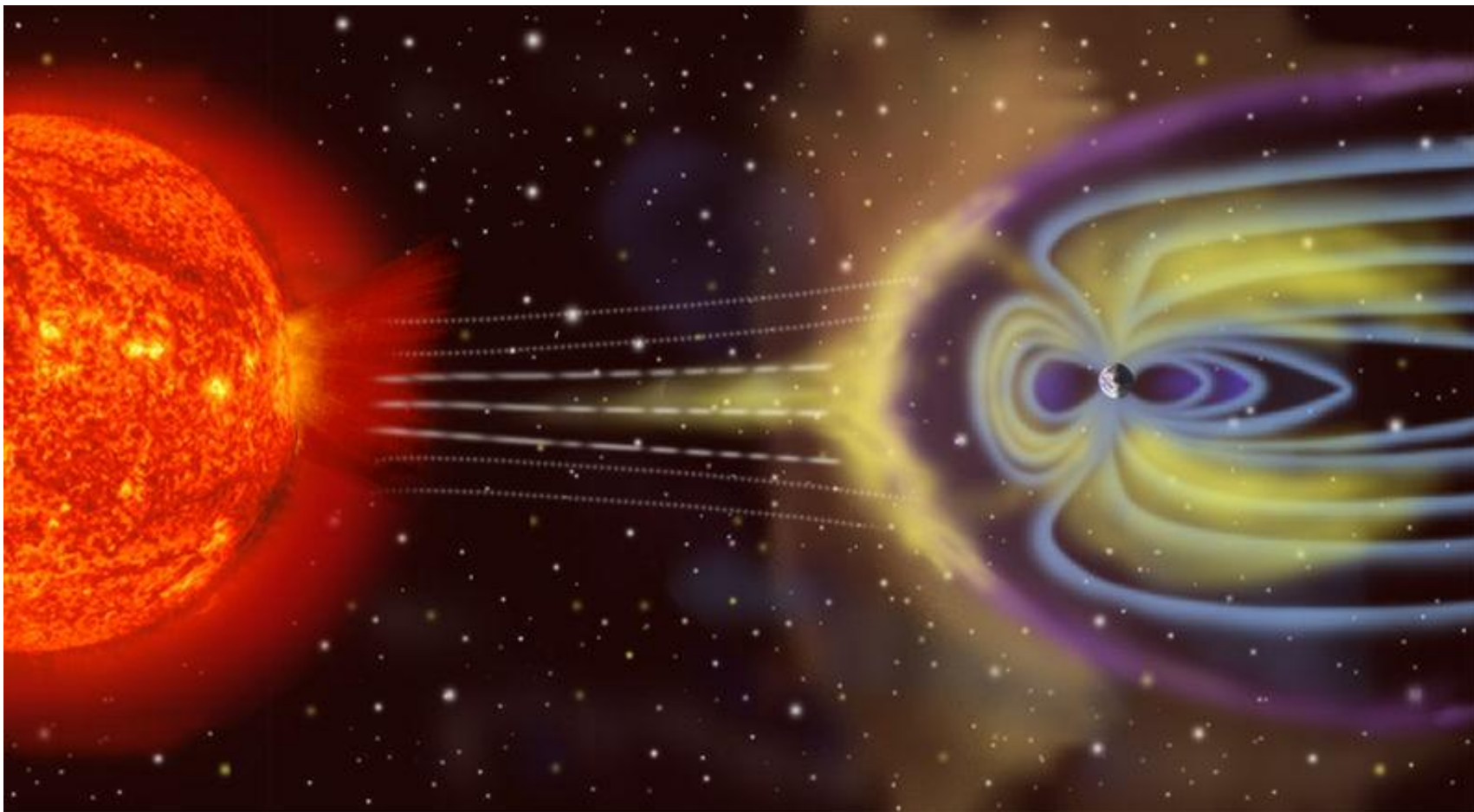


Image not to scale

[Movie](#)



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SWx L2+ Algorithms

QUESTIONS?